Compatibility Test System for Use With the Mark III DSN Data Subsystems Implementation

A. I. Bryan
DSN Systems Engineering Office
G. H. Winn
DSN Facility Operations Office

This article reports on the Compatibility Test System (CTS) that will be used at the Compatibility Test Area, JPL, Pasadena (CTA 21), and the Spacecraft Compatibility/Monitor Station, Merritt Island, Florida (STDN MIL 71), to perform telecommunications compatibility tests with the Mariner Jupiter-Saturn 1977 and the Pioneer Venus 1978 spacecraft. The functional design of the new system utilizes capabilities provided by a Compatibility Test Assembly and the Mark III DSN Data Subsystems (MDS) configuration. A discussion of the Compatibility Test System implementation identifies the special-purpose equipment which comprises the Compatibility Test Assembly.

I. Introduction

Implementation of the Mark III Deep Space Network Data Subsystems (MDS) at the Compatibility Test Area, JPL, Pasadena (CTA 21), and the Spacecraft Compatibility/Monitor Station, Merritt Island, Florida (STDN MIL 71), necessitates a redesign of the Compatibility Test System (CTS) used to verify telecommunications compatibility between a spacecraft and the Deep Space Network (DSN). The new CTS, as designed by the DSN Systems Engineering Office, will be developed and implemented at CTA 21 to support the Mariner Jupiter-Saturn 1977 Spacecraft–DSN Compatibility Test Program, which starts during the second quarter of calendar year 1976. The test system will provide capabilities to satisfy both Mariner Jupiter-Saturn 1977 and Pioneer Venus 1978 Compatibility Test Program requirements.

II. Functional Design

The functional design of the Compatibility Test System is based on the following criteria:

(1) Implement a test capability for use at CTA 21 and MIL 71 to provide test monitor, control and simulation capabilities which will satisfy Mariner Jupiter-Saturn 1977 and Pioneer Venus 1978 Compatibility Test Program requirements.

(2) Provide a cost-effective implementation of the Compatibility Test System through utilization of the capabilities provided by the Mark III DSN Data Subsystems for test control and performance monitoring.

The Compatibility Test System hardware for Mariner Jupiter-Saturn and Pioneer Venus 1978 will consist of a Compatibility Test Assembly interfaced to a standard Mark III DSN Data Subsystems configuration at CTA 21 or MIL 71. The Compatibility Test Assembly contains special-purpose equipment that provides the capability to measure and analyze analog signals. Other compatibility test requirements will be met by utilization of the standard MDS capabilities for control, monitoring and simulation.

The functions of measurement, processing and reporting of analog signals will be performed by specialized applications software. Each applications program will perform as a high-priority task under the control of Operating System software. The standard Modular Computer Systems Corporation (MODCOMP) Operating System (MAX III) software will be extended to provide an analog input capability and a plotting capability to support the applications programs.

The Compatibility Test Assembly Controller will process analog information to perform two functions:

(1) Measure the phase stability of a spacecraft's transmitted carrier and telemetry subcarrier(s). Phase stability measurements are performed in real time by concurrently sampling the phase detector error signals of two ground receivers which are phase-locked with the spacecraft's downlink carrier. The root-mean-square (rms) voltage from either receiver indicates the phase noise of the receiver plus that of the spacecraft's transmitter. Cross-correlation of these two signals, displayed in the frequency and time domains, provides a measurement of the phase noise contributed by the spacecraft's transmitter. Subcarrier phase stability measurements utilize the same technique by sampling two subcarrier demodulators.

(2) Measure the relative power of the components of a spacecraft's transmitted radio-frequency signal and provide a frequency domain plot of the spectral components. Measurements of a spacecraft's transmitted spectrum components are performed by digitizing an analog recording of a spacecraft's transmitted RF signal. Time samples of the radio-frequency signal are transformed to the frequency domain by a Fast Fourier Transform algorithm. The resulting phase components of the frequency spectrum are processed to provide discrete spectral components of power. All power components are converted to relative values and referenced to the carrier. The resulting plot contains frequency and relative power values for each discrete spectral component.

The Compatibility Test System, by utilizing capabilities provided by the Mark III DSN Data Subsystems implementation, will also provide the following:

(1) Control and monitor of tests to determine the performance of a spacecraft's Command, Telemetry and Radio Metric Subsystems under simulated nominal and worst-case flight conditions. Test control and monitoring will be performed from a central input/output terminal.

(2) Spacecraft Radio Frequency Subsystem (RFS) tests utilize the control capabilities of the Block IV Receiver–Exciter and the special CTA 21/MIL 71 Microwave Subsystems. These subsystems provide capabilities to simulate doppler and to measure the acquisition characteristics and tracking performance of the spacecraft receiver.

III. CTS Implementation

Implementation of the Compatibility Test System requires an extension of the Mark III DSN Data Subsystems capabilities. This extension is provided by the Compatibility Test Assembly interfaced to the Communications Monitor Formatter (CMF) Assembly and special-purpose test software, which resides on the CMF Assembly Disk. The CMF redundant MODCOMP Model II-25 minicomputer is utilized as the Compatibility Test Assembly Controller.

Special-purpose equipment required to implement the Compatibility Test Assembly will be housed in one standard DSN 48-centimeter (19-inch) roll-around rack and will interface with the redundant CMF minicomputer through a single cable connected to an existing plug on the CMF Peripheral Controller Interface (PCI) Connector Panel. Only one set of Compatibility Test Assembly equipment will be procured for use at both CTA 21 and MIL 71. Upon completion of testing at JPL and prior to

initiation of testing in Florida, the Compatibility Test Assembly equipment will be shipped from CTA 21 to MIL 71.

It should be noted that when the Compatibility Test Assembly is interfaced to the CMF redundant minicomputer, it will in no way disturb the hardware integrity of the standard CMF Assembly. The Compatibility Test Assembly interface merely extends the input/output bus capabilities of the standard CMF Assembly configuration.

The new Compatibility Test Assembly consists of the following equipment:

(1) A twelve-bit Analog-to-Digital (A-D) Converter and Power Supply.

(2) A twelve-bit Digital-to-Analog (D-A) Converter and Power Supply.

(3) A Peripheral Controller Interface Assembly, which contains the A-D and D-A Interface Logic.

Standard MDS configuration equipment that will be used in conjunction with the Compatibility Test Assembly to provide the CTS capability consists of:

(1) The CMF redundant minicomputer.

(2) A General Electric TermiNet keyboard-printer as normally connected in the standard CMF Assembly configuration.

(3) A Varian high-speed printer-plotter as normally connected in the standard CMF Assembly configuration.

(4) The direct access storage device (Disk) that is part of the standard CMF Assembly configuration.

The block diagram in Figure 1 illustrates the hardware configuration of the Compatibility Test System functional capability.

The software packages to be used by the CTS will consist of:

(1) The standard DSN Operational Software Package used to process Telemetry, Command, Radio Metric and Monitor data.

(2) A software package consisting of a version of the standard MDS Operating System (MAX III) extended to handle the interface between the Compatibility Test Assembly and the CMF's MODCOMP minicomputer, and containing applications programs such as Phase Jitter Analysis and Downlink Spectrum Analysis. Applications programs will be prepared in Fortran IV (a standard software package on the MODCOMP II).

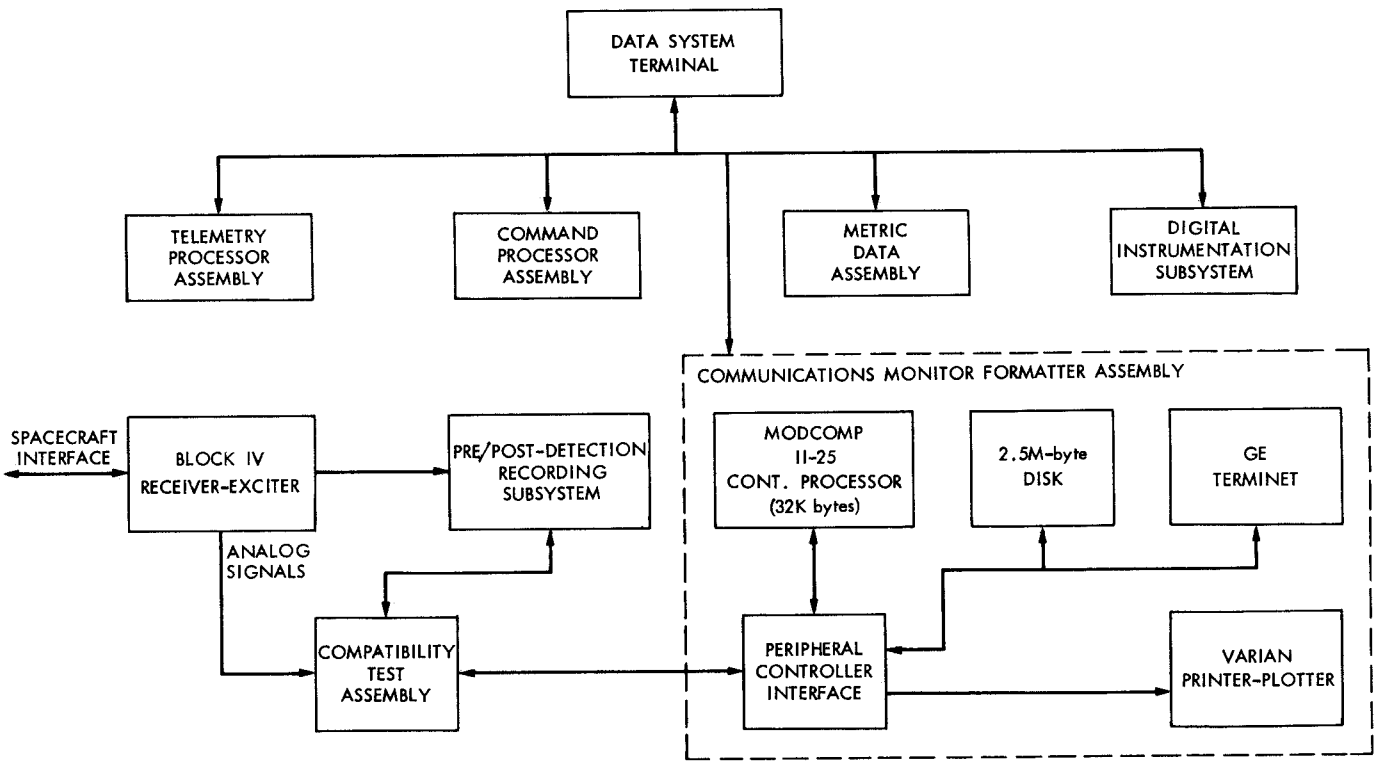

Fig. 1. Compatibility Test System configuration for CTA 21 and Mil 71